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Carbofuran Applications Fail to Reduce Damage to Seeds and Cones of Scotch Pine in North Dakota and Nebraska

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Treating infested scotch pine trees with 113 g, 227 g, or 340 g of 10% carbofuran granules per 2.54 cm d.b.h. did not reduce the number of Scotch pine cones damaged by *Dioryctria* spp. in North Dakota or Nebraska. The number of seeds damaged by *Leptoglossus occidentalis* in Nebraska appeared to decrease with increasing carbofuran concentration.

Keywords: *Dioryctria* spp., *Leptoglossus occidentalis*, *Pinus sylvestris*, coneworms, seedbugs, Furadan, insecticides, impact

Management Implications

Carbofuran granules (10%) were applied to mineral soil within the drip line of Scotch pine (*Pinus sylvestris* L.) trees at rates of 113 g, 227 g, or 340 g per 2.54 cm (inch) of tree diameter, during 1976 and 1977. The number of cones damaged by coneworms (*Dioryctria* spp.) in North Dakota or Nebraska was not reduced by these applications.

The number of seeds damaged by the seedbug, *Leptoglossus occidentalis* Heidmann, tended to decrease with increased carbofuran concentrations, although the reduction was not significant. In contrast, application of carbofuran to southern pine species in the southeastern United States has reduced damage by both *Leptoglossus corculus* (Say) and to a lesser extent *Dioryctria* spp. (DeBarr 1976).

In the North Dakota Scotch pine provenance test plantation, damage by the cone worm, *Dioryctria disclusa*, occurred before mid-June. About 49% of the damaged cones aborted before August, leaving only 51% of the damaged cones still on the tree when the mature cones were collected in the fall. Cones damaged by *Dioryctria* spp. did not release seeds at maturity in 88% of the North Dakota sample and in 56% of the Nebraska sample.

More research is needed to determine if Scotch pine trees absorb carbofuran, where the carbofuran is translocated in the pines, and what concentration of carbofuran is needed to prevent seed damage in Scotch pine. Also more research is needed in the semiarid northern and central Great Plains environment to determine what levels of soil moisture are needed to dissolve carbofuran and insure uptake by tree roots.

Introduction

Improved cultivars of Scotch pine (*Pinus sylvestris* L.) are being developed for use on the Great Plains in Christmas tree, ornamental, and shelterbelt plantings. Tree improvement research is hampered when high value cone crops are damaged by insects, such as coneworms (*Dioryctria* spp. Zeller) and seedbugs (*Leptoglossus* spp. Guerin). Coneworm larvae feed on male strobili, female strobili, and the first- and second-year cones. Adult seedbugs suck out the contents of seeds and pollen sacs (Hedlin et al. 1980).

Cone and seed insects severely damaged control-pollinated cones in Scotch pine provenance plantings, in 1975, at the Denbigh Experimental Forest, in North Dakota, and at the University of Nebraska Horning State Farm, near Plattsmouth, Nebraska. Second-year cones at Denbigh were mined by *Dioryctria disclusa* Heinrich[2], whose larvae may feed on as many as two Scotch pine cones. Because the larvae burrow into the axis of the cone, virtually every infested cone dies (Mattson 1976). Cones at the Horning State Farm were damaged by *Dioryctria* spp. and seeds were emptied by *Leptoglossus*

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occidentalis Heidmann.[2] At each location, annual cone crops with more than $3,000 invested in labor alone were destroyed.

Tests by DeBarr (1976, 1978) and Neel et al. (1978) have resulted in the registration of carbofuran (Furadan)[3] for control of seed and cone insects in southern pine seed orchards. Carbofuran may help reduce insect damage in other parts of the United States. Granules of this highly toxic insecticide can be applied with minimum risk to the applicator, and in advance of insect activity and peak field work. This note describes a field experiment to determine the effect of *Dioryctria* spp. and *L. occidentalis* damage on seed crops in two widely separated Scotch pine plantings.

Study Areas

Denbigh Site

The plantation at Denbigh consisted of trees representing 33 geographic seed sources of Scotch pine established on a 5-acre plot, in 1961. Most sources are replicated 24 times in one-tree plots. The trees are 4.8 m apart, 7.4 to 9.0 m tall, about 20 cm d.b.h. with a 4.5-m crown diameter.

Horning Farm Site

The Scotch pine planting at the Horning plantation in Nebraska consisted of 36 sources planted in 1961, in 4-tree plots, replicated 7 times. Many seed sources duplicate those in North Dakota. Tree sizes and spacing also were similar to those at Denbigh.

Methods and Materials

The following treatments of carbofuran were applied at each plantation:

1. Control—no carbofuran
2. 113 g of 10% granules per 2.54 cm (inch) d.b.h.
3. 227 g of 10% granules per 2.54 cm (inch) d.b.h.
4. 340 g of 10% granules per 2.54 cm (inch) d.b.h.

In each plantation, 96 trees in one-tree plots were randomly selected to receive one of the 4 treatments. Each treatment was applied to 24 trees. There was at least one tree between each two treatment trees, to serve as a buffer.

Carbofuran applications were made in late April at Denbigh Experimental Forest, and in early April at the Horning Farm. To assure rapid incorporation of carbofuran into the mineral soil, litter within the tree dripline—about a 3-m radius around the tree—was removed in 1976. A 1-gallon can with holes punched in the bottom was used to broadcast the Furadan granules uniformly on the exposed ground. The litter was raked back over the treated area to prevent birds and other wildlife from eating the toxic granules. Because of an unusually dry spring, all trees at Denbigh were irrigated once in mid-May with about 284 liters of water per tree to help dissolve the carbofuran. Because a heavy rain fell immediately after the Furadan application at the Horning Farm, the trees there were not irrigated.

In 1977, the length of time needed to treat each tree was reduced by removing the litter from a 0.33-m wide ring located half way between the dripline and trunk of each tree. The carbofuran was applied to the mineral soil in a 0.1- to 0.15-m wide band around the tree. The ring was recovered with litter and then was rototilled. In mid-May and early June, the rototilled ring around each tree at Denbigh was irrigated with 284 liters of water. Trees at the Horning Farm were not irrigated because of several heavy rainfalls following treatment.

After the cones had matured in the fall of 1975 and 1976, a 25-cone sample was randomly collected from each test tree at both plantations. Cones were examined for *Dioryctria* spp. damage and then were allowed to dry on trays in the greenhouse. The extracted seeds were dewinged, separated by an air blower into full and empty categories, and counted. Separation accuracy was checked by X-raying 10% of the sound and empty seed for 9 seconds, at 20 MV and 3 MA, with a Picker Hotshot X-ray unit.

Five conelets on each sample tree at Denbigh were tagged in early May 1977 and were checked on June 5, June 23, and July 22 for signs of abortion. Insect or other damage to surviving cones also was noted.

Results and Discussion

Denbigh Site

In 1977, second-year Scotch pine cones at Denbigh averaged 44.6 mm long. Cones yielded an average of 13.4 seeds in 1976 and 20.9 seeds in 1977.

The percentage of cones damaged by *Dioryctria* spp. in 1976 and 1977 did not vary with treatment. Insect damage to cones in untreated trees dropped from an average of 16.7% to 3.2% in 1977 (table 1). This reflects a drop in the 1977 *D. disclusa* population. Seeds were not released from 79% to 88% of the cones damaged by *D. disclusa* in 1976 (table 1). No data were available for 1977. *Dioryctria* spp. damage, which was usually found at the cone base, adversely affected subsequent seed development and seed release.

Irrigation of the test trees, which was intended to increase the possibility that toxic doses of carbofuran would accumulate at sites of *Dioryctria* activity, did not result in control.

Across all treatments, only 64 of the 458 tagged cones were damaged by *Dioryctria* spp. during the 1977 growing season. Although fewer cones were damaged in the

[2] *The* Dioryctria disclusa *were identified by A. Mutuura, Biosystematics Research Institute, Agriculture Canada, Ottawa, Ontario.* Leptoglossus occidentalis *was identified by G. DeBarr and H. O. Yates, USDA Forest Service, Southeastern Forest Experiment Station, Athens, Georgia.*

[3] *The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture of any product or service to the exclusion of others which may be suitable.*

Table 1.—*Dioryctria* spp. and bird damage to cones and seeds, cone size, and yield in Scotch pine trees at Denbigh, 1976 and 1977

Year and parameter measured	Treatment (g carbofuran per 2.54 cm d.b.h.)			
	0	113	227	340
1976				
No. cones sampled	431	506	499	492
Cones damaged by *Dioryctria*—No. (%)	72 (16.7)	90 (17.8)	103 (20.7)	86 (17.5)
Damaged cones releasing seeds—No. (%)	8 (11.1)	18 (20.0)	19 (18.4)	18 (20.9)
Damaged cones retaining seeds—No. (%)	64 (88.9)	72 (80.0)	84 (81.6)	68 (79.4)
Average No. seeds per cone ± S.D.	12.8 ± 5.64	13.3 ± 7.14	18.0 ± 5.12	13.3 ± 8.40
1977				
No. cones sampled	493	424	467	413
Cones damaged by *Dioryctria*—No. (%)	16 (3.2)	19 (4.5)	15 (3.2)	19 (4.6)
Average cone length—mm ± S.D.	45.1 ± 6.4	43.2 ± 6.4	45.2 ± 6.4	44.7 ± 6.4
Average No. seeds per cone ± S.D.	20.8 ± 10.34	22.0 ± 7.93	21.7 ± 10.89	16.9 ± 8.62
Cones damaged by birds—No. (%)	51 (10.3)	34 (8.0)	37 (7.9)	48 (11.6)

340-g treatment than in the 113-g and 227-g treatments, this reduction was not statistically significant (table 2).

Fifty-six cones (87.5%) were damaged before June 5, or within 2 weeks after control-pollination; 5 cones (7.8%) between June 5 and June 23; and 3 cones (4.7%) between June 24 and July 22. All damage by *D. disclusa* occurred before June 23. Cone damage after June 23 was caused by other species of *Dioryctria*.

Twenty-nine of the 64 damaged cones aborted as a result of *Dioryctria* spp. activity (table 2)—3 cones (10.3%) by June 5; 12 cones (41.4%) between June 5 and June 23; and 14 cones (48.3%) between June 24 and July 22. Approximately 50% of the damaged cones aborted at each of the three lowest treatment rates, while fewer than 33% aborted at the highest rate (table 2). Scotch pine cones need about 12 weeks to complete development. Because *Dioryctria* damaged cones aborted during July, a survey of insect damage to cones based on cones harvested could underestimate *Dioryctria* spp. damage by as much as 48%. DeBarr (1974) also observed that counts of infested second-year slash pine cones collected in mid-September underestimated the total impact of *Dioryctria* spp. Twenty of the 458 tagged cones were missing and were assumed to have aborted from unknown causes. Their periodic losses were: 10 cones (50%) before June 5; 3 cones (15.0%) between June 5 and June 23; and 7 cones (35.0%) between June 24 and July 22.

As expected, no seedbug (*Leptoglossus occidentalis*) damage to seeds in the sample cones was noted at Denbigh. Unknown prefertilization and developmental problems caused the empty seeds. Seed eating birds, such as crossbills, pine siskins, and black-capped chickadees, also can damage cones while extracting seeds from them. In 1977, an average of 9.5% of the sample cones were damaged by birds.

Horning Farm Site

In 1977, average length of the cones collected at Horning was 41.7 mm. Average yield of seeds per cone was 17.9 in 1976 and 16.5 in 1977.

The level of carbofuran application did not affect the percentage of cones damaged by *Dioryctria* spp. in Nebraska (table 3). Only 6.2% to 5.5% of the cones collected in the control treatments at the Horning Farm were damaged by *Dioryctria* spp. in 1976 and 1977, respectively.

Of the cones damaged on trees in the control treatment, 51.3% failed to release their seeds in 1976 and 59.3% in 1977. Thus, the quantity of seed collected was reduced by more than 50% in these two years because of *Dioryctria* spp. cone damage.

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